Electromagnetic Induction (EM) for monitoring of soil-moisture pattern at the hill-slope scale

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Knowledge about spatially distributed soil-moisture pattern and its temporal dynamics is a key issue for understanding and modelling hydrologically triggered landslides. Because traditional measurements based on soil samples probe are very limited area or volume of the subsurface, 2D electrical resistivity tomography (ERT) is more frequently used for qualitatively monitoring soil-moisture variability. However, the effort for ERT increases significantly with increasing field sizes. Furthermore, cultivation of land can hamper the installation of permanent electrode arrays.
Ground-based electromagnetic induction (EM) methods have proven to be an efficient technique for a quick and area-wide mapping of soil electrical conductivity. We conducted several EM mapping surveys at the Heumöser site in Vorarlberg, Austria, which is a complex and slow-moving landslide area. EM surveys focus on the open space areas, which are used as pasture in summer and ski slope in winter. Using the EM-Profiler (EMP-400, GSSI), we repeatedly collected data over one year. Due to changing weather conditions over the period of EM monitoring, raw data have to be standardized to an equivalent conductivity at a reference temperature of 25°C. Furthermore, any unwanted external influences on the EM response have to be eliminated or corrected. As a result, we obtained standardized maps of interpolated electrical conductivity that allow for calculating differences between selected surveys, the delineation of slope areas with different dynamics, or the zonation of the slope area based on statistical cluster method. When assessing the EM maps, one should keep in mind that apparent electrical conductivity is a sum parameter, influenced by various soil components such as soil texture, water content, and mineral content. Since soil texture and mineral content are static features, variations in apparent electrical conductivity can be attributed to relative soil-moisture variability. EM monitoring is thus a suitable tool for the characterization or partitioning of the survey area prior to the installation of data logger, or monitoring relative changes in soil conditions.